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Research Note

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN, UTAH 84401

USDA Forest Service
Research Note INT-125

December 1970

PLANTING METHOD AFFECTS HEIGHT GROWTH OF PONDEROSA PINE
IN CENTRAL IDAHO

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ABSTRACT

SEP 30 1971

Analyses of planting tests conducted over 5 years and of growth of ponderosa pine (Pinus ponderosa Laws.) seedlings over 10 years have shown that seedling survival and height growth are improved by careful handling and planting of stock in areas stripped of brush. When compared on a common age basis, 2-0 planting stock grows as tall as 2-1 stock. The study also showed that: (1) trees 2 to 3 feet from a cut bank grow taller than trees 6 to 7 feet from the bank; (2) height growth increases steadily for the first 10 years; (3) height variations increase with seedling age; and (4) site evaluations must take into account highly variable growth rates.

PROCUREMENT SECTION
CURRENT SERIAL RECORDS

Planting methods have long been known to affect the growth of ponderosa pine (*Pinus ponderosa* Laws.).² Methods that give greatest seedling survival generally result in best growth characteristics also. Ponderosa pine planting tests in central Idaho have shown that both percent survival and height growth can be increased if brush is removed from planting sites and nursery stock is carefully handled. These increases imply that reduced competition lessens the impact of natural selection and that site evaluations may be overly conservative as a consequence.

¹Respectively, Silviculturist, stationed in Boise, Idaho, and formerly Principal Silviculturist, stationed in Boise, presently retired.

²Harry C. Turner. The effect of planting method upon growth of western yellow pine. J. Forestry 16: 399-403. 1918.

THE TOWN CREEK PLANTATIONS

A 5-year planting test that incorporated three site preparations and three nursery stock-handling methods was initiated in 1954.³ The test area was in the small Town Creek drainage, 11 miles northwest of Idaho City, Idaho, on the Boise National Forest. Within the Town Creek drainage, major slopes fall gently to the southeast, but tributaries form subbasins containing all aspects and slopes to 50 percent. Based on young growth in the vicinity, Site Quality IV⁴ predominates.

The Town Creek drainage is within the 45,000 acres of the 1931 Quartzburg burn. Since the fire, the ground has supported little tree growth. Instead, it has sustained a broken to dense complex of brush species, dominated by snowbrush ceanothus (*Ceanothus velutinus* Dougl.).

SITE PREPARATION

Planting sites, three 8-foot-wide lanes, were contoured around the slopes. A D-7 Caterpillar⁵ tractor was used to strip vegetation from two of the lanes. Two furrows made by Talledega plows were added to one of these lanes, but the third lane was left in its natural state; i.e., no brush was removed before planting.

NURSERY STOCK CLASSES

The three nursery stock-handling classes were known as: 2-1⁶ "regular," 2-1 nursery stock transported by common carrier and planted by the slit method, a conventional forestry practice; 2-1 "special," 2-1 nursery stock transported by Forest Service trucks and planted by the dug-hole method; and 2-0 "special," 2-0 nursery stock transported by truck and planted by the dug-hole method.

Thus, nine treatment combinations were compared. These treatments were randomly assigned to nine parallel lanes. Specified stock was planted in two rows 4 feet apart on each lane. Trees were spaced 6 feet apart in the rows. About 90 acres were restocked each spring from 1954 to 1958.

TREE HEIGHT SAMPLING

Tree heights on selected aspects were measured during the fall months of 1959 and 1968. In 1959, heights to the first and second whorls (after planting) were recorded for the five plantations and heights to the fifth whorl were recorded for the 1954 and 1955 plantations. In 1968, heights to the tenth whorl (after planting) were recorded for the five plantations. Different trees were used for each height period measurement.

Sampling areas were carefully selected; areas in which soils were obviously shallow or height growth noticeably depressed were bypassed. Two aspects, easterly and westerly, were sampled in each of the five annual plantings. On each aspect, a starting line was arbitrarily specified that crossed the nine strips. The entire aspect was systematically sampled by measuring 15 trees on each lane.

³James D. Curtis and Melvin A. Coonrod. The Town Creek ponderosa pine plantation. Soc. Amer. Forest. Proc. 1960: 21-25. 1961.

⁴Walter H. Meyer. Yield of even-aged stands of ponderosa pine. U.S. Dep. Agr. Tech. Bull. 630, 59 p., illus. 1938. (Revised April 1961).

⁵Mention of trade names is solely for identification and does not necessarily imply endorsement by the USDA Forest Service.

⁶The first digit indicates the number of years stock has been in an initial nursery bed (a seeded bed), the second, the number of years in a transplant bed; e.g., a 2-1 seedling would be 3 years old.

A lack of randomness in the sampling precludes a rigorous statistical evaluation of height attainment. However, the breadth of sampling, the random assignment of treatments, and the measurement of all nine treatments at each sample location suggest that an analysis of variance for differences in height has some credibility. A 3 X 3 factorial design was used. Each analysis cell includes measurements from the five annual plantings on two selected aspects (15 trees per aspect, 150 tree heights).

The 1-year age difference between 2-0 and 2-1 stock implies a height difference. In some instances, in order to compare stock on a common base, we estimated height of the 2-0 stock 1 year after measurement. We calculated the periodic annual height growth for the measurement period and added it to the actual height. In every case but one, *careful planting and handling resulted in increased growth each period*, regardless of site preparation.

HEIGHT RELATIONSHIPS

Height evaluations were planned to take into account the influence of site preparation and of planting stock. Analysis of variance for common-base heights at 10 years indicates highly significant differences ($p=.01$) between all treatments:

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Site preparation (SP)	2	1063.4917	531.7458	236.668**
Planting stock (PS)	2	137.7035	68.8517	30.644**
SP X PS	4	16.1406	4.0351	1.796 NS
Error	1341	3013.0259	2.2468	
Total	1349	4230.3584		

** Significant at the .01 level.

NS Not significant at the .05 level.

The interaction term was not significant.

Turning now to a secondary analysis, growth conditions adjacent to cut banks differ from conditions at the soil surface or on fill areas. Height differences were compared by means of a *t* test for paired plots. Data are included to permit survival-height comparisons.

Site preparation.--No stock treatment nor site preparation method affected survival and height more than brush removal. Five years after planting, survival in brush was 42 percent or less, survival on stripped rows exceeded 71 percent. Ten years after planting, mean seedling heights were:

Treatment	Mean heights (Feet)
No site preparation	3.18
Stripped	5.06
Stripped and furrowed	5.05

100
100
100
100

100

100
100
100
100

100

100
100

Figure 1.--Contrast the height of a tree planted on an unprepared site (left) with that of a tree planted at the same time on stripped ground (right).



The range in mean heights for trees in brush was 2.86 to 3.54 feet and on stripped ground, 4.69 to 5.64 feet.⁷ Height of trees in brush averaged 57 to 66 percent of the height of trees on stripped ground (fig. 1). Site preparation improved both survival and height growth.

Planting stock.--Stock that was carefully handled and planted grew taller, regardless of site preparation (Table 1). Tenth-year mean tree heights were:

<i>Stock class</i>	<i>Mean heights (Feet)</i>
2-0 "Special"	4.22
Common age base (est.)	(4.64)
2-1 "Special"	4.88
2-1 "Regular"	4.19

The mean annual height growth for the full life of the seedling was used as the basis for making comparisons of all treatments (table 2). At the last year measurement, the 2-1 "special" stock had shown the fastest growth rate, and the 2-0 "special" stock had grown as fast as or faster than the 2-1 "regular." The influence of stock handling and its importance are indicated by these two comparisons.

The increasing rate of height growth is apparent over the three growth periods (tables 2 and 3). The rate should stabilize in the next 10-year period.

Unfortunately, the performance of planting stock is contingent upon several factors that cannot be ignored. From an operational standpoint, the most important of these is the planting method. Production for the dug-hole method ranged between 160 and 180 trees per day, for the slit method, 340 to 400. Differences of this magnitude and the costs they represent would influence operational decisions. It was unfortunate the study design did not provide for direct comparison of planting methods.

⁷Slight differences between means of the two treatments were not significant. (George W. Snedecor. P. 253 in: Statistical Methods. Ed. 5, 534 p., illus. Ames, Iowa: The Iowa State Coll. Press, 1956.)

Table 1.--Periodic seedling heights and survival percents, Town Creek Plantations, Boise N.F.

Nursery stock		Combination of treatments								
(Years since planted):	(Seedling age):	None			Stripped			Stripped and furrowed		
		2-0 ¹	2-1	2-1	2-0	2-1	2-1	2-0	2-1	2-1
		special	special	regular	special	special	regular	special	special	regular
SEEDLING HEIGHTS ²										
----- Feet -----										
2	4	0.48			0.61			0.54		
	5	³ (0.60)	0.61	0.57	(0.76)	0.72	0.62	(0.67)	0.68	0.59
5	7	1.39			2.03			1.83		
	8	(1.59)	1.61	1.33	(2.31)	2.37	1.88	(2.09)	2.31	2.15
10	12	2.86			4.98			4.80		
	13	(3.10)	3.54	3.10	(5.39)	5.44	4.75	(5.20)	5.64	4.69
10-year range		0.5-5.5	0.5-7.0	0.9-6.0	0.9-9.4	1.4-10.0	0.9-9.1	1.0-8.9	1.4-10.3	0.4-8.8
SEEDLING SURVIVAL ⁴										
----- Percent -----										
2	4	52.5			87.7			87.9		
	5		72.5	51.3		99.3	83.9		97.0	91.7
5	7	31.9			74.7			79.9		
	8		42.1	23.4		85.5	71.8		93.1	82.5
5-year range		16-42	39-59	12-35	72-88	82-91	71-76	79-80	90-95	79-83

¹The first digit indicates the number of years stock has been in an initial nursery bed (a seeded bed), the second, the number of years in a transplant bed; e.g., a 2-1 seedling would be 3 years old.

²Basis: 150 trees in each cell.

³Parenthetical values are estimates calculated by adding the periodic annual increment to the height at the end of the period.

⁴Basis: 12.7M to 21M trees per cell.

Natural variation.--Ten years after planting, the treatment combination with the tallest trees had the greatest height range:

Mean heights (Feet)	Height range (Feet)
5.64	9.2
5.44	8.6
4.98	8.5
4.80	7.9
4.75	8.2
4.69	8.4
3.54	6.5
3.10	5.1
2.86	4.5

Parallel trends are evident. Apparently slow starters continued growing slowly; fast starters fast.

1000

1000

1000

1000

1000

Table 2.--Mean annual height growth 2, 5, and 10 years after planting,
Town Creek Plantations, Boise N.F.

Nursery Stock		Site Preparation								
(Years since planting): age	(Seedling)	None			Stripped			Stripped & furrowed		
		2-0 ¹	2-1	2-1	2-0	2-1	2-1	2-0	2-1	2-1
		special	special	regular	special	special	regular	special	special	regular
----- Feet -----										
2	4	0.120			0.152			0.135		
	5		0.122	0.114		0.144	0.124		0.136	0.118
5	7	.198			.290			.261		
	8		.201	.166		.296	.235		.289	.269
10	12	.238			.415			.400		
	13		.272	.238		.418	.365		.434	.361

¹The first digit indicates the number of years stock has been in an initial nursery bed (a seeded bed), the second, the number of years in a transplant bed; e.g., a 2-1 seedling would be 3 years old.

Table 3.--Periodic annual height growth 2, 5, and 10 years after planting,
Town Creek Plantations, Boise N.F.

Nursery Stock		Site Preparation								
(Years since planting): age	(Seedling)	None			Stripped			Stripped & furrowed		
		2-0 ¹	2-1	2-1	2-0	2-1	2-1	2-0	2-1	2-1
		special	special	regular	special	special	regular	special	special	regular
----- Feet -----										
2	4	0.120			0.152			0.135		
	5		0.122	0.114		0.144	0.124		0.136	0.118
5	7	.300			.473			.430		
	8		.333	.420		.550	.420		.543	.312
10	12	.294			.590			.594		
	13		.386	.574		.614	.574		.666	.508

¹The first digit indicates the number of years stock has been in an initial nursery bed (a seeded bed), the second, the number of years in a transplant bed; e.g., a 2-1 seedling would be 3 years old.

Figure 2.--Cut bank, stripped of brush in 1954, is shown as it appeared in 1968.



Data show that variance increased with size, a well-documented phenomenon.⁸ Seed from many stands growing under different environmental conditions probably were mixed together in the nursery each year. Additional mixing of genetic characteristics no doubt occurred in lifting, shipping, and planting. These factors suggest that the variation in heights at any given age should be greater than that found in natural stands.

In addition, a broader range of inherited growth capacities survive because improved conditions for regeneration and establishment reduce the impact of natural selection. When the stands are thinned, management selection can replace natural selection by keeping trees best adapted to these sites. At times, height growth may be only a partial indicator of a tree's adaptability and survival potential.

Cut banks.--Trees planted 2 or 3 feet from a cut bank of 1 or 2 feet in depth (fig. 2) may have different growth conditions than trees 6 or 7 feet from the bank. From a subsample of all treatment combinations on a 1957 planting, we found that 12-year-old trees in the row next to a bank averaged more than 0.3 foot taller (8.55 feet) than trees in the outside row (8.19 feet). This difference is significant at the 95 percent level.

Influence of competition.--It is logical to assume that competition between brush and ponderosa pine seedlings has an effect on seedling height similar to that observed in overdense stands. The height-retarding influence of overstocking and its effect on site index evaluations has been described by Lynch.⁹ The Town Creek results appear to be consistent with Lynch's findings. However, we can expect height growth to accelerate soon after the crowns clear brush level and the trees become dominant.

⁸Donald R. Gedney and Floyd A. Johnson. Weighting factors for computing the relation between tree volume and d.b.h. in the Pacific Northwest. U.S. Forest Serv., Pacific Northwest Forest and Range Exp. Sta. Res. Note 174, 5 p. 1959.

⁹D. W. Lynch. Effects of stocking on site measurement and yield of second-growth ponderosa pine in the Inland Empire. U.S. Forest Serv., Intermountain Forest and Range Exp. Sta. Res. Pap. 56, 36 p. 1958.

Cognizant of the potential for error in site index evaluations, let us consider the magnitude of such an error. Project a stand planted in brush to, say, the year 2000. Then consider a traditional site index evaluation based on total age and height. It is apparent that volume on a brush site would be underestimated when compared to that on stripped ground. Of course, the magnitude of the error is variable, but (we suspect) appreciable in many cases. A 2-foot difference in height value for 20-year-old ponderosa pine (S.I.=80) represents 4 to 5 index units--a 5 to 10 percent difference in estimates of cubic foot volume at 50 years.¹⁰ Much of this potential error, the result of wide variation in juvenile conditions, can be removed by using age at breast height as a variable in developing site index curves.

WHAT WAS LEARNED

Land managers must frequently base decisions on incomplete or inadequate data. Before 1954, regeneration practices in the Intermountain Region gave little hope for success. By 1958, survival in the Town Creek Plantations had pointed the direction to successful plantings. An unanswered question was: How well will the seedlings grow? Thousands of acres required planting; so the Region managers moved ahead without waiting for this question to be answered. Stripping was the site preparation, 2-0 seedlings were given special handling, and the slit method was used for planting. Height growth results have supported their decisions.

As a result of this study, we conclude that:

- 1.--Brush competition restricts seedling height growth;
- 2.--Brush removal improves both seedling survival and height growth;
- 3.--Nursery stock that is carefully handled and planted grows taller;
- 4.--On a comparable age basis, 2-0 ponderosa pine stock grows about as well as 2-1 stock;
- 5.--Trees 2 to 3 feet from a cut bank grow taller than trees 6 or 7 feet from the bank; and
- 6.--The rate of seedling height growth increases steadily for the first 10 years.

¹⁰Meyer, *op. cit.* p. 2.

